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SCIENTIFIC ARTICLE

Bromatological and morphological characteristic of forage plants

Característica bromatológica y morfológica de las plantas forrajeras

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ABSTRACT

To a better decision in relation to the choice of forages, it is important to know its bromatological and morphological characteristics, since this knowledge can lead to greater productivity and quality of dry mass forage. This work aimed to evaluate the morpho-physiological characteristics of forage plants, specifically *Urochloa brizantha* cv. Xaraés/MG-5*; Urochloa brizantha* cv. Marandu*; Panicum maximum* cv. Mombaça*; Urochloa brizantha* cv. BRS/Piatã*; Urochloa brizantha* cv. Paiaguás. The experiment was carried out at the College of Agricultural and Technological Sciences, Dracena, São Paulo, Brazil, May 2015. Bromatological, physiological and morphological analyses of the leaves were performed. The cultivar *Urochloa brizantha* cv. Marandu excelled in mineral matter (MM%); and Xaraés for dietary fiber in acid detergent (FDA%). The cultivar *Urochloa brizantha* cv. Xaraés/MG-5 was distinguished in the parameter thickness of the adaxial epidermis (TAdE), mesophyll thickness (MT); diameter of leaf phloem (LDP) and diameter of leaf xylem (LDX). The cultivar *Urochloa brizantha* cv. Paiaguás highlighted in the parameter thickness of the abaxial epidermis (TAbE). In general, the cultivar *Urochloa brizantha* cv. Xaraés/MG-5 presented the best results regarding the morphological characteristics of the studied forage plants.
Keywords: Bromatology, morphology, *Urochloa* spp., *Panicum* maximum

RESUMEN

Para una mejor decisión en relación con la elección de los forrajes, es importante conocer sus características bromatológicas y morfológicas, ya que este conocimiento puede llevar a una mayor productividad y calidad del forraje de masa seca. Este trabajo tuvo como objetivo evaluar las características morfofisiológicas de las plantas forrajeras, específicamente *Urochloa brizantha* cv. Xaraés / MG-5; *Urochloa brizantha* cv. Marandu; *Panicum maximo* cv. Mombaça; *Urochloa brizantha* cv. BRS / Piatã; *Urochloa brizantha* cv. Paiaguás. El experimento se llevó a cabo en la Facultad de Ciencias Agrícolas y Tecnológicas, Dracena, São Paulo, Brasil, mayo de 2015. Se realizaron análisis bromatológicos, fisiológicos y morfológicos de las hojas. El cultivar *Urochloa brizantha* cv. Marandu sobresalió en materia mineral (MM%); y Xaraés para fibra dietética en detergente ácido (FDA%). El cultivar *Urochloa brizantha* cv. Xaraés / MG-5 se distinguió en el parámetro de espesor de la epidermis adaxial (TAdE), espesor de mesofila (MT); diámetro del floema de la hoja (LDP) y diámetro del xilema de la hoja (LDX). El cultivar *Urochloa brizantha* cv. Paiaguás resaltó en el parámetro espesor de la epidermis abaxial (TAbE). En general, el cultivar *Urochloa brizantha* cv. Xaraés / MG-5 presentó los mejores resultados en cuanto a las características morfológicas de las plantas forrajeras estudiadas.
Palabras clave: Bromatología, morfología, *Urochloa* spp*., Panicum maximum*

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INTRODUCTION

Brazil is one of the countries with the greatest potential for the production of cattle in pasture system due to its weather conditions and its territorial extension (Rueda et al., 2020). In this context, the importance of the rational use of natural resources is evident, as well as the knowledge regarding the environments where pastures are inserted, such management and systems of animal production can be planned and implemented without risk to sustainability and agricultural yield (Deniz et al., 2020).

Brazilian production of beef cattle maintains itself by using grass a food source for animals due to its low cost of production. However, a big part of pastures is inserted in Brazilian Cerrado, which present low fertility and is frequently exploited by extractivists, entailing a dynamic degradation process of the soil (Maia et al., 2021).

Knowing and quantifying the nutritive value of pastures is an important step to the better choice regarding the forage that will be used, as well as its suitable management. That way, the nutritional value of forage is set by the soil fertility in which it is inserted as well as the weather conditions, physiological age and used management (Pezzopane et al., 2015). Several attributes are linked to the nutritional values of forage, but the low values are associated with the diminished value of crude protein and minerals, with high content of fiber and low digestibility of dry mass (Soest, 1994).

The knowledge of the diverse characteristics of each one of the forages for their proper choice and use is very importance, since it aims to guarantee the productivity and the perenniality of the crops, as well as the gains of the productive systems. Therefore, this work aimed to evaluate the morpho-physiological characteristics of forage plants.

MATERIALS AND METHODS

Installation of the experiment

The experiment was carried out in January 2015, in the College of Agricultural and Technological Sciences, Dracena, São Paulo, Brazil; with the following coordinates 21°27’34.393”S and 51°33’19.215” W and altitude around 370 m.

The seeds used in experiment were obtained from a production company in Dracena, São Paulo State, Brazil. Five varieties were studied: *Urochloa brizantha* cv. Xaraés/MG-5*; Urochloa brizantha* cv. Marandu*; Panicum maximum* cv. Mombaça*; Urochloa brizantha* cv. BRS/Piatã*; Urochloa brizantha* cv. Paiaguás. A completely randomized design was used, with five repetitions.

Seeds were sown at 5cm-depth in vases with volumetric capacity of 9 dm^3 and 490.6 cm^2 of area, filled with Dystrophic Red-Yellow Argisol (Embrapa, 2013), which was previously sifted and fertilized, according to Raij et al. (1996). Vases were kept in a greenhouse covered with transparent film plastic light diffuser with 1000 microns. During the growth term, vases were watered whenever necessary, respecting the field capacity of soil.

Bromatological analysis

Thirty days after installation of the experiment, the aerial part was dried and carried to the Laboratory of Bromatology, at College of Agricultural and Technological Sciences, Dracena, to perform the analysis. After pre-drying, they were milled in a Willey-type knife mill with a 1 mm sieve. The following bromatological analyzes were performed: dry mass (DM%); mineral matter (MM%); crude protein (CP%); dietary fiber in neutral detergent (FND%); dietary fiber in acid detergent (FAD%), according to by Soest, Robertson & Lewis (1991).

Physiological analysis

Before cutting the aerial part, also at the thirtieth day, it was set the chlorophyll index (CI), by directly reading with chlorophyll reading device (CCM-200). The reading was carried out between 10am and 12am, under full sun, in +1 leaves totally expanded. In the same leaf, stomata conductance (COND) was sere, thought Porometer Model AP-4 at the same time of day.

Morphological analysis.

At the same time of samples collecting, the morphological analyses of forage leaves were done. Four pieces of around 5 cm were taken from the middle part of the leaves (leaf +1) from the apex of the stem. The pieces were fixed in solution FAA70 (37% formaldehyde, glacial acetic acid and 70% ethanol in the proportion of 1.0: 1.0: 18.0 - (V / V) and stored in 70% ethanol until the date of analysis. Where they were submitted to all necessary laboratory processes, such as: dehydration, diaphanization, inclusion and embedding (Kraus & Arduin, 1997).

A cross-section of 08 micrometers (μm) was performed with a microtome on each leaf fragment containing the central vein. A histological slide was assembled for each stuck material in which the first cross section was chosen, which presented the most preserved material, without damage or injury caused by the cut in the plant tissues. Sections were stained with 1% safranin and mounted on slide and coverslips with adhesive for fixation. The measurements of leaves’ parameters were done in central vein, with an optical microscope Olympus® brand BX43 model, with attached camera to perform photos of the slides. Photos were used to the measurements of the anatomical parameters with the software of images analysis CellSens Standart, with a microscopic ruler in photos zoom, as described by Figueiredo, Ramos, Viana, Lisboa & Heinrichs (2013).

The following leaves’ anatomy parameters were set: thickness of adaxial epidermis (TAdE); thickness of the abaxial epidermis (TAbE); thickness of adaxial cuticle (TAdC); thickness of abaxial cuticle (TAbC); mesophile thickness (MT); diameter of the leaf phloem (LDP); and diameter of leaf xylem (LDX).

Statiscal analysis

The results were submitted to the F test ($p<0,05$) and its average compared by the Turkey Test, at 5% probability (Banzatto & Kronka, 2013). Statistic program Assistat 7.7 was used. (Silva & Azevedo, 2016).

RESULTS AND DISCUSSION

As Table 1 shows, to the content of dry mass, Mombaça presented the greatest result. Notably, animals productivity is entailed by structural characteristics of the vegetal, specifically the proportion of leaves, which is directly linked to production of dry mass (Maia et al., 2021).

Average values of dry mass, mineral matter and crude protein, dietary fiber in neutral detergent, dietary fiber in acid detergent are expressed in chemical and bromatological composition of forages. They play an important role and are responsible for the quantitative and qualitative analysis of forage. These parameters, besides the total dietary nutrients and *in vitro* digestibility of dry mass, may have a direct or indirect influence on the voluntary consumption of dry mass, consequently, on animal production (Soest, 1994).

Regarding the mineral matter content, Marandu presented the highest value, followed by BRS/Piatã and Paiaguás. The mineral composition of forages plants varies according to independent factors, such as plant age, soil fertility, used fertilization, the difference between the species and season in which they are consumed by the animals. The lower concentration of minerals in the plant may occur due to a minor concentration of minerals in soil, a diminished genetic capacity of mineral accumulation, or even an indication of smaller needs of the plants to its growth regarding minerals. Similarly, higher concentrations, even in toxic levels, are indicative of its excess in soil, plant genetic capacity of higher accumulation, or greater need of minerals for its growth (Lisboa et al., 2021).

Crude protein did not display significant difference between the studied forages and none of the values performed under 21%. According to Soest (1994), values under 7% of crude protein lead to a reduction of its digestibility by animals due to the unsuitable amount of nitrogen available for rumen microorganisms, entailing the decrease of population and diminishing digestibility of dry mass.

Similarly, significant difference was not observed in dietary fiber in neutral detergent (FND%), which presented values above 42%. Garcia-Amezquita, Viacava, Jacobo Velázquez (2020) affirms that dietary fiber in neutral detergent (FND%) is the most limiting factor regarding the bulky food consumption by animals. Values above 55% in cell wall negatively influence forage consumption. That way the concentration of dietary fiber in neutral detergent (FND%) is directly linked to animal consumption.

Xaraés presented the highest value of dietary fiber in acid detergent (FAD%), values around 40%, or above, lead to a low consumption by the animals, as well as to a smaller digestibility (Skamarokhova, Yurina, Bedilo, Yurin & Ashinov, 2020; Hansen, et al. 2021). Malafaia, Valadares Filho, Vieira, Silva & Pedreira (1997) found levels of 80.45% FND and 44.94% FDA for *Brachiaria brizantha* cv. Marandu cuts during the rainy season.

Average values of morpho-physiological analyzes of leaves different forage leaves are displayed in Table 2.

Chlorophyll index (CI) presented a significant difference between the forages species, once Piatã presented the highest value, followed by Xaraés/MG-5 (Table 2). Bazame, et al. (2020) found similar values by studying the consortium of corn with the *Urochloa brizantha* species associated with nitrogen fertilization. The authors highlight the presence of nitrogen is a limiting factor to the concentration of chlorophyll in forages, agreeing with (Costa et al., 015).

Table 1. Medium values Dry mass (DM%); mineral matter (MM%); crude protein (CP%); dietary fiber in neutral detergent (FND%) and dietary fiber in acid detergent (FAD%) of aerial part of different forages. Dracena, 2015.

	DM (%)	MMi (%)	CP (%)	FND (%)	FAD (%)
Xaraés/MG-5	9.29bc	12.07ab	23.15	45.70	40.18a
Marandu	8.50c	13.37a	23.82	42.12	27.54b
Mombaça	11.15a	10.86b	24.37	47.41	37.64ab
BRS/Piatã	9.08bc	11.92ab	23.27	46.94	38.27ab
Paiaguás	9.97ab	12.85ab	21.79	42.63	35.64ab
MSD	1.38	2.03	5.58	9.19	11.25
CV (%)	7.59	8.80	12.64	10.79	16.55
F	9.62**	3.97*	0.53ns	1.27ns	3.44*

** - significant at 1% of probability (p<0.01); - significant at 5% of probability (0.01=<p<0.05) and NS - non-significant (p<0.05); MSD: Minimum significant difference. CV: Coefficient of variation. F: value of F calculated in the analysis of variance. The averages in the column followed by the same letter do not differ statistically from each other. The Tukey test was applied at a 5% probability level. By author.

Table 2. Average values of chlorophyll index (CI); stomata conductance (COND); thickness of adaxial epidermis (TAdE); thickness of abaxial epidermal (TAbE); thickness of adaxial cuticle (TAdC); thickness of abaxial cuticle thickness (TAbC) of different forage species. Dracena, 2015.

	CI	COND μmol m^{-2} s^{-1}	TAdE μm	TAbE μm	TAdC μm	TAbC μm
Xaraés/MG-5	26.94ab	344.50	15.74a	14.17ab	4.13	3.98
Marandu	22.75bc	321.52	14.44ab	13.08ab	3.72	3.85
Mombaça	17.03cd	234.98	12.07b	11.90b	3.82	3.69
BRS/Piatã	33.36a	272.75	13.63ab	13.90ab	3.92	3.88
Paiaguás	14.51d	284.99	13.98ab	14.70a	3.82	3.76
MSD	7.87	130.18	3.60	2.41	1.20	0.84
CV (%)	18.12	23.53	13.60	9.38	16.41	11.66
F	16.69**	1.93ns	2.45*	3.69*	0.30ns	0.31ns

** - significant at 1% of probability (p<0.01); - significant at 5% of probability (0.01=<p<0.05) and NS - non-significant (p<0.05); MSD: Minimum significant difference. CV: Coefficient of variation. F: value of F calculated in the analysis of variance. The averages in the column followed by the same letter do not differ statistically from each other. The Tukey test was applied at a 5% probability level. By author.

Regarding the stomatal conductance (COND), no significant effect was found among the evaluated species. A lower stomata conductance is an indicative that the vegetal diminishes its transpiration due to the closure of its stomata, entailing a smaller fixation of atmospheric carbon to the production of dry mass (Luna-Guerrero et al., 2020), which impairs the vegetal’ development. However, as described above, Monbaça presented a higher value to the content of dry mass (DM%), without demonstrating a significant difference in stomata conductance.

Also, the opening and closure process of the stomata is closely related to light intensity. That way, the results may be linked to the reflex of high intensity light, which closes the stomata cleft, resulting in no difference among the treatments. Under high temperatures, the highest carbon assimilation rate can be inhibited by diminishing the stomata conductance (Cabrera, Hirl, Schaufele, Mcdonald & Schnyder, 2021).

To the characteristic thickness of adaxial epidermis (TAdE), *Urochloa brizantha* cv. Xaraés/MG-5 presented the highest average value, as *Urochloa brizantha* cv. Paiaguás highlighted in the thickness of adaxial epidermis (TAbE). The epidermis is often subjected to different changes in its structure, once it is in direct contact with the environment. Epidermal cells are usually uniseriate, live and vacuolated. Besides, they are juxtaposed, without spaces between them. Thess characteristics are very important, since one of the functions of epidermis is restrict the loss of water (Castro, Pereira & Paiva, 2009).

The thickness of adaxial cuticle (TAdC) and thickness of abaxial cuticle thickness (TAbC) did not present significant difference in the studied species. Biotic and abiotic stress may influence ihe epidermal thickness of leaves (Lisboa et al., 2021). As the main functions of these issues are the protection of the vegetal’ surface and gas exchange, including steam, plants that contain epidermis may protect their mesophile against several injuries (Carrizo et al., 2020).

Table 3. Average values of mesophile thickness (MT); diameter of the leaf phloem (LDP); and diameter of leaf xylem (LDX) of forages. Dracena, 2015.

	MT μm	**LDP μm**	**LDX μm**
Xaraés/MG-5	170.00a	5.32a	22.12a
Marandu	110.21b	4.50ab	15.97b
Mombaça	126.51b	5.01ab	19.44ab
BRS/Piatã	121.22b	4.08b	21.30a
Paiaguás	129.62b	4.40ab	16.10b
MSD	30.17	1.13	3.58
CV (%)	12.10	12.87	9.97
F	10.21**	3.41*	11.43**

** - significant at 1% of probability (p<0.01); - significant at 5% of probability (0.01=<p<0.05) and NS - non-significant (p<0.05); MSD: Minimum significant difference. CV: Coefficient of variation. F: value of F calculated in the analysis of variance. The averages in the column followed by the same letter do not differ statistically from each other. The Tukey test was applied at a 5% probability level. By author.

According to Queiroz-Voltan, Rolim, Pedro Júnior & Hernandes (2011), change in mesophile may seriously interfere in photosynthesis capacity, as well as in vegetable production

Average values of other morphological analyses in different species of forages are available in Table 3.

Urochloa brizantha cv. Xaraés/MG-5 highlighted among the studied varieties regarding the characteristic mesophile thickness (MT), presenting the highest average. Meziane & Shipley (1999) verified that alterations in the volume of mesophilic cells, in number of mesophile layers, in amount of intracellular spaces in mesophile, in thickness of veins or cell walls, leading to changes in thickness of leaves. In this way, forage adaptations become a strategy for selecting the different species where they will be inserted, seeking their greatest productive and quality potential in dry matter Figueiredo et al. (2019)

Regarding diameter of the leaf phloem (LDP) and diameter of leaf xylem (LDX), *Urochloa brizantha* cv. Xaraés/MG-5 presented the greater averages. The parameter diameter of leaf xylem (LDX) had similar results in *Urochloa brizantha* cv. BRS/Piatã and Xaraés. Greater diameter of the leaf phloem (LDP) favors the transport of photoassimilates to the storage places, entailing a faster growth of plants and shading of space in cultivation areas. Lisboa et al. (2021) concluded that environmental factors positively influence on dimension and composition of vascular elements as an attempt of promoting safer transport when the vegetal is under any kind of stress.

CONCLUSIONS

Urochloa brizantha cv. Marandu highlights in mineral matter (MM) and as Xaraés does in dietary fiber in acid detergent (FAD%).

Urochloa brizantha cv. Xaraés/MG-5 presented better results in the following characteristics: thickness of adaxial epidermis (TAdE); diameter of the leaf phloem (LDP) and diameter of leaf xylem (LDX)

Urochloa brizantha cv. Paiaguás presented the best results regarding thickness of the abaxial epidermis (TAbE)

In general, *Urochloa brizantha* cv. Xaraés/MG-5 highlighted regarding morphological features among the studied forages species.

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